**A case for integrated systems research**

*In the second phase of Africa Rising Research Project, integrated system research (ISR) will identify, evaluate and adapt technological, farm management, institutional and policy interventions to improve household income and nutrition, reduce poverty and improve healthy ecosystem functioning. Through capturing diversity in farms and farming systems and analyzing multi-scale and multi-dimensional interactions, systems research identifies promising SI options for scaling. Furthermore, the assessment of current system limitations helps articulating the necessary enabling conditions to accrue benefits in equitable ways, avoiding externalities.*

Integrated Systems Research (ISR) provides tools and approaches to identify, design, test and adapt **solutions to problems** plaguing rural livelihoods that (i) have positive impacts on the different realms constituting livelihoods (e.g., food and nutrition security, income, natural resource integrity), (ii) respect equity between households, communities, and different stakeholder groups is respected, and (iii) are sustainable in economic, social, and environmental terms.

**Integrated Systems Research is needed** because farm households and communities face numerous and complex decisions as system managers themselves. It thus recognizes that improving the productivity or income-generation of a single production unit within a smallholder farm can happen at the cost of other production units, leaving a net negative effect on farmer’s livelihoods. Similarly, improving the livelihood status of a single farming family can happen at the cost of livelihoods of other, often poorer, families. The avoidance of unintended consequences, both within and amongst households, is another key goal of ISR. Well-executed ISR can deliver significant advantages in terms of the adoptability of innovations as it implicitly recognizes that this is not just governed by factors that are intrinsic to that innovation. Innovation that has been evaluated in a more holistic, systems context will have been more robustly evaluated for its adoptability. Moreover, effective prioritization, targeting and scaling is not possible without a view of the relative importance of the threats and opportunities that farmers face in managing different system components together. An arbitrary focus on a specific system component without a proper understanding of its contribution to overall household livelihoods is likely to reduce the ultimate relevance of the research.

In alignment with these goals, ISR embraces **approaches** that:

1. Aim at place-based system intensification and diversification beyond increases in single crop productivity.
2. Pursue system intensification by minimizing trade-offs and exploiting synergies and complementarities between system components particularly tree-crop-livestock-soil-water interactions.
3. Allow to address contrasting stakeholder perspectives that differ in prioritization of the system dimensions of productivity, natural resource integrity as well as policies, markets, and institutions.
4. Differentiate and explicitly address diversity of farming systems, e.g. in endowment and efficiency, thus allowing nuanced approaches to scaling up of best-fit technologies.
5. Strengthen the science-policy interface that will enhance government and international bodies’ delivery of changes on the ground to rural people, by basing research prioritization on sound diagnostics in which all potential stakeholders are given the opportunity to participate.

ISR fosters connectivity with markets and value chains and collaboration among farming households, communities and development partners, through partnership platforms for collective prioritization, decision-making, and implementation. The activities and components in agricultural systems interact, and ISR can help to quantify and foresee how proposed changes affect the overall performance of the system for different productive, socio-economic and environmental indicators. As such, ISR allows putting newly developed innovations and technologies in a larger perspective. By doing this, the focus operates at multiple scales and across multiple domains, for example by evaluating what the effect of a new crop variety is on biophysical aspects of the farm and landscape (e.g., productivity, mitigation of pollution), but also on socio-economic aspects of the household and community (e.g., income, gender equity).

ISR addresses the **heterogeneities** in landscapes and populations that are encountered when deploying innovations to larger target groups and scaling out. It acknowledges that the requirements for innovation and adaptation are dependent on the local biophysical conditions and on the endowment and socio-institutional setting of the household. Therefore, various methods such as spatial analysis and household typologies are available to analyze these heterogeneities and to exploit them to support scaling out of technologies. These are absolutely essential for effective targeting and ensuring and characterizing the scaling potential of the innovations that are generated. Moreover, ISR can analyze the dynamics of systems over time, thus allowing assessment of interventions risks and thereby guiding a stepwise approach towards, for instance, the sustainable intensification of agricultural production.

Since ISR focuses on multiple performance dimensions (or goals) of systems at the same time, it allows **quantifying** **tradeoffs and synergies** among indicators in a straightforward and intuitive way. Because it provides insight into implications of adoption and behavioral changes at larger scales beyond the plot level, it is highly suitable for evaluation of development outcomes and can support identification of appropriate policy instruments, e.g. to choose between different incentive schemes and extension efforts.

The tools used in ISR thus allow the construction of **‘what if’ scenarios** and exploration of windows of opportunity for future development and system dynamics. These explorations can be performed under different scenarios of changes in external conditions such as policies, markets, and biophysical and climatic conditions. This allows a quantitative assessment of adaptability and resilience to for instance climate change, policy regimes and market volatility.

The perspective of ISR on innovation and impact is **broader than monitoring of adoption of technologies** per se, and comprises three strongly related dimensions:

1. The potential for change, i.e. the availability of options to adapt and improve management systems, such as new practices and technologies, focusing on the possibilities for implementation and adaptation of a basket of technologies and reconfigurations of existing practices, rather than use of single technologies.
2. The preparedness to implement changes from the basket of technologies, which is determined by human factors such as the competence (ability and flexibility) of land managers and by the support and incentives that they receive from their socio-institutional environment.
3. The performance of alternative system configurations, which involves an evaluation of the effects of the changes on productive, environmental and socio-economic performance indicators.

To reach impact, ISR can assist in identification of leverage points by assessing the potential for change and by improving the competence (knowledge, skills, etc.) and connectedness (social networks, community and institutional support, etc.) of system managers.

**EXAMPLES**

**Example from Ethiopia (illustrative picture can be provided):**

A study conducted by Africa RISING in the Ethiopian Highlands has explored some possible reasons for non-adoption or dis-adoption of improved variety x management practice packages for faba bean. It was based on the hypothesis that smallholders do not use improved management practices because these do not adequately improve upon the ***overall*** benefits that farmers derive from faba bean plots under traditional management. The project’s diagnostic studies showed that farmers deliberately weed their faba bean fields much later than is recommended for improved management systems. This creates the opportunity for volunteer “weeds” like oats and Trifolium spp. – species that are in fact relatively nutritious fodders – to create an *ad hoc* forage intercrop in areas with limited grazing land. A cost benefit analysis revealed that the opportunity costs associated with the loss in weed biomass when the improved practices were adopted were not adequately offset by the economic gains from increased grain yield and crop residue biomass. By taking a broader, systems perspective we could clearly see that using the terms “improved” and “weed” indiscriminately and without properly understanding the multiple benefits that farmers derive from the plots they cultivate can be highly misleading. Accepting these terms uncritically can also lead to misperceptions of farmer irrationality because they do not adopt “improved” practices. Studies such as this one are demonstrably more informative and help us to identify more adoptable intensification strategies.

**Example from Tanzania (illustrative picture can be provided):**

Babati district is one of two Africa RISING action sites in Tanzania where nutrient mining has been established in 65% of farms but with only 3% reported to use (foliar) fertilizer, in large part being a myth that fertilisers spoil soils, which grew out of a fertiliser scaling exercise that was wrongly implemented. Scientists set out to address both the nutrient mining and myth by introducing technological packages to be promoted with flexibility, including allowing for partial or stepwise adoption, where these present opportunities. As a first step, researchers demonstrated that basic agronomy should be a starting point towards higher productivity. Demonstration of intercropping of improved (drought-resistant) maize, bean and pigeon pea varieties with complimentary application of fertiliser following the 4R (right source, rate, time, place) of nutrient stewardship for the target crops.

## Cover and fodder crops known for high nitrogen fixation and soil and water conservation have been introduced into specific niches, e.g. on terraces for sloping fields, as relay in farm fields, and also dependent upon the erodibility risk, livestock feed requirements, household nutritional needs, marketability, risk reduction among others.

These trials are complemented by a full suite of climatic parameters which are being collected in real time by automated weather stations and supplemented with data collected by farmers from manual rain gauges deployed in farmers’ compounds. Soil moisture measurements help reinforce the research design to ensure that soil moisture balance measurements will inform the fate and transport of nutrients within and beyond the crop rooting zone for accurate recommendations of nutrient management regimens. The scaling and delivery of improved agricultural technologies will be highly dependent on good quality data which in turn leads to informed choices by smallholder farmers, and to improved decision making (modeling) with increased chances of successful scaling elsewhere.

**Example from Mali: Exploring the solution space for sustainable intensification**

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In the Guinea Savannah areas of Southern Mali, yields for major crops have largely stagnated over the past 20 years. With low population density and ample land available, farmers in the Bougouni district have limited incentives to intensify. This scenario analysis explores the solution space to show the potential and the limitations of sustainable intensification (SI) pathways, leading to a better understanding of the required enabling conditions to lift the system to a higher level of performance. The study considers an entire population of farms to assess the diversity of benefits within a community. The scenarios include the baseline at median yields (“50%” in the figures) yield gap narrowing to 90th percentile yield values through SI (“90%” in the figures), gross margin maximization through crop area re-allocation (“optimized” in the figures), and addition of improved cowpea varieties tested in AfricaRISING trials (“with cowpea” in the figures).

Description: profits - optimization

Figure 1. Gross margins per active household member for different scenarios. The solid line is the 1.25 US$/person/day extreme poverty level, the dashed line is 2 US$/person/day. Median yields are used in the 50% scenarios; 90th percentile yields are used in the 90% scenarios. Farms are ranked from smallest to largest along the X-axis.

Description: foodsec-opt

Figure 2: Household food self-sufficiency status in the scenarios described in Figure 1. In the optimization scenarios with cowpea, food self-sufficiency is lower than for the other scenarios, because of low cowpea grain yields. Median yields are used in the 50% scenarios; 90th percentile yields are used in the 90% scenarios. Farms are ranked from smallest to largest along the X-axis.

Given current technology and economic conditions, farmers have limited room to maneuver. Optimizing crop allocation provides few benefits in terms of income, indicating that farmers are obtaining near-maximum profits given their generally low yields (Figure 1). Farmers in Bougouni may be able to move out of extreme poverty through narrowing the yield gap, but it is difficult for them to move much beyond that without substantial changes to the agricultural system. With most households already food self-sufficient, increasing yields of food crops would specifically benefit the currently food-insecure households (Figure 2), which are generally the low resource endowed farms. In terms of crops already common in the area, groundnut is the most promising option for increasing farm profitability. Moreover, as both men and women grow groundnut, its potential benefit to family food security is substantial. Cowpea is currently not widely grown. However, AfricaRISING trial results show that new varieties and management practices make it potentially profitable, as well as providing another protein-rich food and fodder source. If current barriers surrounding under-developed fodder markets and problematic transportation could be solved, farmers will be able to take advantage of selling cowpea.

Acknowledgements: McKnight Foundation and Drylands Systems CRP

**Example from Mali: Recommendation domains as a result of farming systems analysis**

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The combination of on-farm trials on a large basket of sustainable intensification (SI) options, farmer feedback during field days, participatory scenario development and trade-off analysis allowed identifying recommendation domains for the most promising technologies. In the case of the Koutiala district in southern Mali, these recommendation domains consist of soil types and previous crop in the rotation (Figure 3), elements that are common throughout the cotton zone in southern Mali and can form the basis of out-scaling activities.

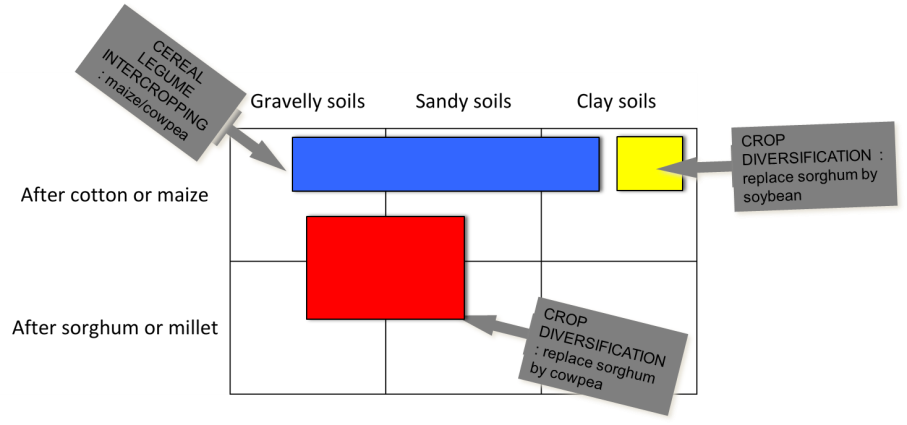
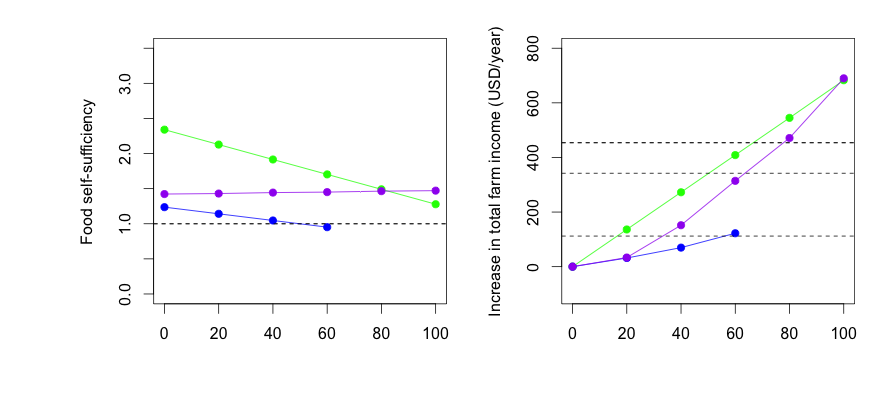


Figure 3: Recommendation domains for three sustainable intensification options in southern Mali.

Adopting the SI options in the identified niches or recommendation domains leads to different outcomes for different types of farmers. Replacing maize sole crops by maize-cowpea intercropping, large farms would benefit in terms of generating more income without compromising food self-sufficiency (Figure 4). At 60% of the maize area, farmers could afford to buy a new cow. Medium farms would notice a strong trade-off between generating more income and achieving food self-sufficiency from replacing sorghum by soybean. However, with a replacement percentage of 60% they could almost buy an ox without becoming food insecure. Small farms would reach a critical food self-sufficiency status at 60% replacement of sorghum by a cowpea grain variety. The resulting increase in income would be enough to buy only one calf.



1 calf

1 cow

1 ox

(b)

(a)

Figure 4: Effects on food self-sufficiency (a) and total farm income (b) of percent replacement by a new option in the recommendation domains identified in Figure 1. The purple line represents the replacement of sole maize by maize-cowpea intercropping for a large farm; the green line represents the replacement of sorghum by soybean for a medium farm; the blue line represents the replacement of sorghum by a cowpea grain variety for a small farm. The dotted lines in (b) represent the investment costs for a calf, a cow and an ox.

Acknowledgements: McKnight Foundation and Drylands Systems CRP

**Example from Ethiopia: place-based implementation of technologies**

One of the preconditions for systems research is ‘placed-based’ implementation of complementary technologies in an integrated manner. In the Ethiopian highlands, a mosaic of interventions has been implemented by different partners to improve system productivity following the landscape continuum (Figure 5). The problem-oriented and site-specific interventions implemented evolved from a community based participatory opportunity and constraint analysis.

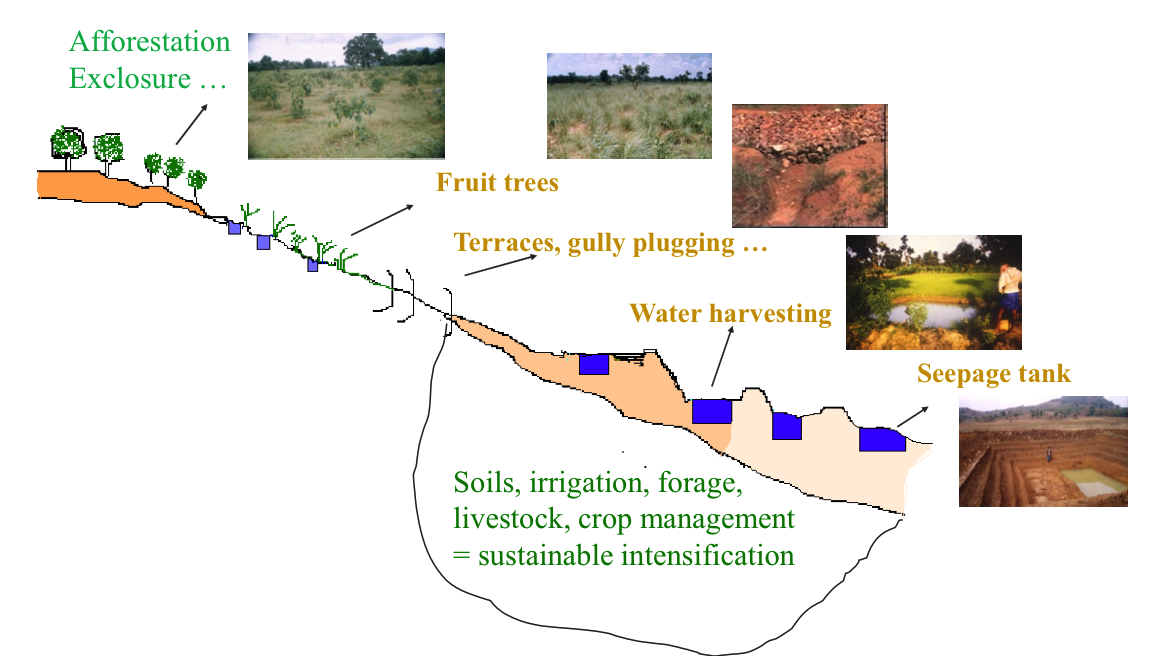


Figure 5. A mosaic of complementary interventions implemented following the landscape continuum to improve overall system productivity.

At the landscape level, sustainable land management (SLM) and soil and water conservation (SWC) options were implemented, especially aimed to restore degraded areas and prevent further degradation. At the plot/farm level, integrated soil fertility management (ISFM) and water harvesting were implemented to improve soil and water productivity. Soil-crop-tree-livestock system integration was designed and implemented to enhance intensification and diversification across the landscapes (from upstream watersheds to farm levels). The conservation and SLM practices were also complemented with productivity enhancing technologies including fruit/vegetable (cash) crops, improved crop varieties, home-gardens, and species for livestock fodder. The project technically supports implementation of the R4D interventions, and use the District/Woreda level Strategic Innovation Platforms (IPs) and the County/Kebele Operational IPs to facilitate cross learning and enhancing technology adoption. The project is developing training modules and capacity development strategies with regards to land and water management, ISFM and system intensification. At the moment, the respective partners who led technology identification are assessing the impacts of the various interventions. There is a need to develop a ‘comprehensive’ tool to analyze the productivity, profitability and resource use efficiency of the interventions. In addition to assessing overall system performance, the tool can also be used for trade-off analysis.